Improvement of Gait Symmetry in Patients with Stroke by Motor Imagery

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Objective: *To investigate effect of gait training with motor imagery (MI) on gait symmetry and self-efficacy of falling in stroke patients.*

Material and Method: *Fourteen stroke patients were categorized in the MI (n = 7) and control (n = 7) groups. They were matched by age range, stroke type, paretic side, time since stroke, and severity. All participants received physical therapy and only the MI group received additional MI training. Both groups were trained for 12 sessions over 1 month. Outcome measurements comprised gait symmetry detecting by the force distribution measurement platform and self-efficacy of falling testing by the Fall Efficacy Scale-International (FES-I). Both groups were assessed three times: pre-, intermediate- and post-trainings. Comparisons of all variables between and within groups were tested by Mann-Whitney U test and Friedman ANOVA test, respectively.*

Results: *No significant difference was observed of gait symmetry between MI and control groups. Within group comparison, tendencies of improvement were found in step length and step time symmetry for the MI group. Significant improvements in step length symmetry and FES-I score were found among assessments for the MI group ($p<0.05$).*

Conclusion: *Gait training with MI enhanced ability of step length symmetry and decreased fear of falling in patients with stroke.*

Keywords: *Motor imagery, Stroke, Gait symmetry, Physical Therapy, Self-efficacy of falling*

J Med Assoc Thai 2015; 98 (Suppl. 5): S113-S118
Full text. e-Journal: *http://www.jmatonline.com*

Asymmetrical gait pattern is usually found in patients with stroke[1]. Because of reduced antagonistic muscle strength, postural balance, and lower extremity function after disease, patients with stroke may move with the compensatory patterns for surviving in their daily activities[1-3]. Abnormalities of movement resulted in increased energy consumption, difficulty to control posture and balance, leading to risk of falling[4].

Many treatment techniques have been developed for correcting asymmetrical gait pattern such as weight bearing training, body-support treadmill training, and task-oriented gait training[5,6]. However, these treatment techniques have limitation in time and instrument requirements, expert dependency, and cost of treatment. Patients with stroke may have limited treatment accessibility as well as lack of confidence in moving caused by therapist dependency.

Motor imagery (MI) is an additional training which activates representation of motor networks in specific functions without overt movement[7]. MI is well-known as a psychological training in sport for enhancing internal capacity[8]. For research, previous studies investigated the effect of MI training in many domains such as brain activities compared with actual movement, healthy, and rehabilitation[9-11].

Regarding neural mechanism during MI and observation of gait, a previous study found brain activation at the dorsal premotor and supplement motor areas while participants had gait imagination and observation[9]. In normal healthy subjects, a study about order and timing during walking and writing in MI and actual movement showed similar temporal correspondence between MI and actual movement for both tasks[10]. MI was used to rehabilitate motor performance in neurological conditions such as patients with stroke and Parkinson's disease[11,12].

In stroke rehabilitation, MI enhances gait performance as demonstrated by improvement of gait velocity, paretic step and stride lengths, Timed Up and Go Test, and Fugl Meyer Assessment for lower extremity score (FMA-LE)[11,13,14]. However, only a few studies

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adopted this technique to enhance gait symmetry in patients with stroke(15,16). Moreover, the benefit of MI training on movement confidence while performing various activities should be determined. Thus, the study aimed to investigate the effects of gait training with MI on gait symmetry and self-efficacy of falling in patients with stroke. The study hypothesized that MI could enhance gait symmetry and confidence of gait function in patients with stroke.

Material and Method

Participants

Fourteen patients with stroke were recruited in the study. Inclusion criteria included: 1) the first stroke diagnosed by neurologist; 2) able to walk independently with or without assisting devices at least 10 meters with asymmetrical gait; 3) score of Modified Ashworth Scale of the knee extensor and ankle plantar flexor muscles $\leq$2; 4) no sensory deficit, and 5) able to communicate and follow commands. All participants received information and signed inform consent forms approved by the Siriraj Institutional Review Board, Mahidol University (607/2555: EC2) before participating in the study. All participants were categorized in MI and the control groups. Both groups received physical therapy (PT) programs but adjunctive MI was provided for the MI group only. Both groups were matched by age range, stroke type, paretic side, time since stroke, and severity determined by the FMA-LE.

Intervention

Participants of both MI and control groups were trained at the Neurological Clinic, Physical Therapy Center, Mahidol University. The PT program consisted of strengthening exercise, decreased muscle tone, functional weight bearing exercise, and task specific gait training. Both groups received PT programs for 50 minutes and additional MI training for 20 minutes only in the MI group. They were assessed three times: pre-, intermediate- (2nd week), and post-trainings (4th week).

The MI training for gait was adapted from the study of Dunsky et al in 2008(15). Firstly, participants contracted and relaxed their muscles and limbs for 5 minutes followed by 10-minute practice focusing on steps during walking using visual and kinesthetic senses. Focusing on steps was started with the non-paretic side followed by the paretic side and both sides by self-pace, individually. After that, they practiced the both steps following the rhythm of a metronome. Lastly, protocol ended with a relaxation period for 5 minutes.

Gait symmetry parameters

Gait symmetry parameters including the step length, step time, stance time, and vertical impulse during stance phase of walking were calculated to obtain the gait Symmetry Index (SI). These were recorded using the force distribution measuring platform (The zebris FDM-System-Gait Analysis, S/N 1243020-0015-0816, Allgau, Germany) at the frequency of 100 Hz. Participants were asked to walk with their normal self-selected speed from start to end of a three-meter platform for 3 trials. Four walking steps at the middle part were used to calculate the mean score. The absolute data of gait SI were calculated from the equation below (3).

$$SI = \left| \frac{(V_{non\text{-}paretic} - V_{paretic}}{0.5\,(V_{non\text{-}paretic} + V_{paretic})} \times 100 \right|$$

The $V_{non\text{-}paretic}$ and $V_{paretic}$ were gait parameters, recorded from the nonparetic and paretic sides, respectively. Scores of gait SI referred asymmetrical gait parameters ranged from 0-200. Zero score indicated perfect gait symmetry and 200 indicated maximum gait asymmetry.

Self-efficacy of falling

The Fall Efficacy Scale-International: Thai version (FES-I) was used to examine self-efficacy of falling(17). It contained 16 questions relating to confidence of falling when performing various activities while sitting, standing, and walking. Scores ranged from 1-4; 1 = indicated no concern, 2 = mild concern, 3 = moderate concern, and 4 = maximum concern.

Data analysis

Due to the small sample size, non-parametric statistical analysis was used to identify the effect of MI training on gait parameters. Gait symmetry parameters (step length, step time, stance time, and vertical impulse symmetries) and FES-I were compared between the MI and control groups at each assessment by the Mann-Whitney U test. In addition, the data were compared within groups among assessments by the Friedman ANOVA test. Pairwise comparisons were tested by the Wilcoxon Sign Rank test.

Results

Table 1 presents demographic data of the participants. They were similar in age, type of stroke,

Table 1. Demographic data of participants in the MI (n = 7) and control (n = 7) groups

Variables	MI		Control	
	n	Median (Q1-Q3)	n	Median (Q1-Q3)
Age (years)	-	60 (51-63)	-	60 (53-63)
Sex (male/female)	6/1	-	4/3	-
Stroke type (ischemic/hemorrhagic)	7/0	-	7/0	-
Paretic side (right/left)	4/3	-	4/3	-
Time since stroke (months)	-	3.5 (2-4)	-	4 (2-4.5)
Gait velocity (m/s)	-	0.42 (0.19-0.55)	-	0.45 (0.19-0.62)
FMA-LE (score)	-	25 (21-26)	-	25 (21-27)

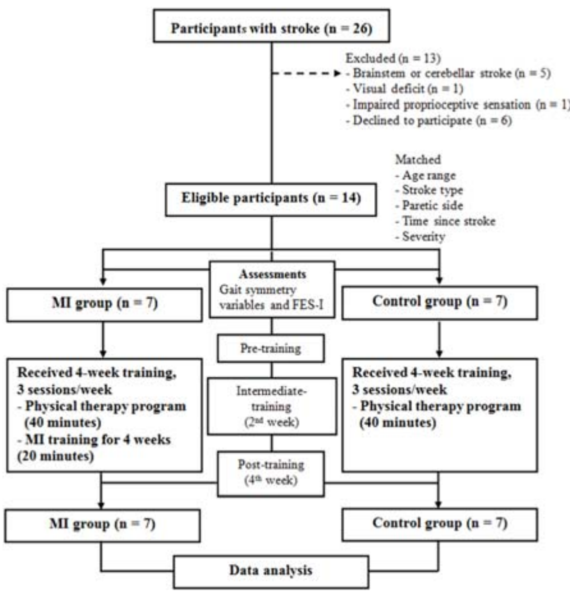

Fig. 1 Flow chart of study procedure.

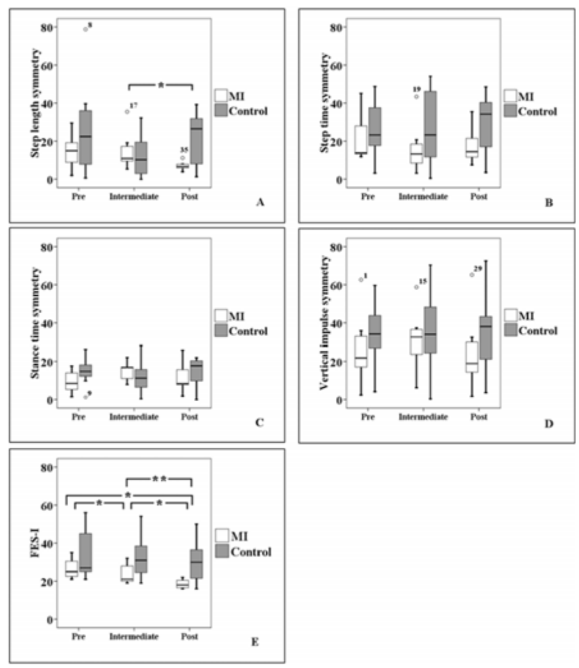

Fig. 2 Box plots and interquartiles of gait symmetry parameters (A, step length symmetry; B, step time symmetry; C, stance time symmetry and D, vertical impulse symmetry) and Fall Efficacy Scale-International among pre-, intermediate-, and post-trainings for the motor imagery (MI) and control groups (*significant difference within group, **significant difference between groups, *p*-value <0.05).

paretic side, time since stroke, and severity. Participants were recruited from Siriraj Hospital and the Physical Therapy Center, Faculty of Physical Therapy, Mahidol University. In all, 26 patients with stroke were included in the study. Thirteen participants were excluded because they did not meet the criteria leaving 14 eligible participants. None of the participants dropped out over the 4-week training for both MI and control groups. Summarization of the study protocol is presented in Fig. 1.

Gait symmetry parameters

Fig. 2 presents comparisons of the gait symmetry parameters and FES-I among pre-, intermediate-, and post-trainings between the MI and control groups. No significant difference was found of the step length symmetry among assessments between the MI and control groups. For within group comparisons, a significant difference was shown in the step length symmetry in the MI group ($p = 0.018$) whereas no significant difference was shown in the control group. Pairwise comparison in the MI group showed significant improvement of the step length symmetry at post-training when compared with the intermediate-training ($p = 0.018$).

Comparing step time symmetry, no significant difference was shown at three times of assessment between the MI and control groups. For within group comparison, no significant difference was found in step time symmetry in both MI and control groups. Comparing to pre-training in the MI group, a tendency was shown of improvement in step time symmetry at intermediate- and post-trainings.

For stance time symmetry, no significant difference was observed among assessments between the MI and control groups. In addition, no significant difference was shown of this variable among assessments in each of the MI and control groups.

For vertical impulse, no significant difference was shown between group comparisons. For within group comparison, no significant difference was shown in both the MI and control groups.

Self-efficacy of falling

A significant difference of the FES-I was found between the MI and control groups at post-training ($p = 0.047$). Among assessments, a significant difference of the FES-I was shown in the MI group ($p = 0.001$) as well as in the control group ($p = 0.050$). Pairwise comparison in the MI group showed significant improvement of the FES-I at post-training when compared with pre- ($p = 0.017$) and intermediate-trainings ($p = 0.017$). In addition, significant improvement of FES-I was shown at intermediate-training when compared with pre-training ($p = 0.017$). For the control group, significant improvement was found at post-training compared with intermediate-training ($p = 0.027$).

Discussion

The authors aimed to investigate the effect of MI on gait symmetry parameters and the FES-I in patients with stroke. Results showed that the MI improved step length symmetry as expected.

The improvement of step length symmetry in the current study was consistent with previous studies[15,16]. One of the possible neural mechanisms underlying the improvement was by the motor network between premotor, supplement motor and primary motor areas[9, 18]. However, the other gait symmetry parameters did not improve after 4 weeks of training.

Sensorimotor impairment associated with a decrease in visual and proprioceptive estimations for responding to environment while performing various functions may lead to high fall risk in patients with stroke[19]. Self-report with the FES-I was one method which assessed fear of falling while performing activities relating to standing and walking tasks[17]. The present study used MI to enhance ability in visual and proprioceptive estimation while walking by visual and kinesthetic imagery. A great improvement in confidence to perform activity in patients with stroke was found after MI training in the MI group. In contrast, the control group presented increased fear of falling while performing activities.

Conclusion

Step length symmetry and FES-I improved after gait training using the MI technique. The study may be limited by the small sample size. Future studies should determine the effect of MI on other clinical gait outcome measures.

What is already known on this topic?

Few studies have reported the effect of MI on improving gait performance in patients with stroke. This training technique is used as an additional therapy after general practice of physical therapy to enhance the treatment effect. However, association of gait symmetry and confidence of walking after MI training have never been determined before. This study investigated the effect of MI training on gait symmetry and efficacy of falling in patients with stroke.

What this study adds?

Improvements of step length symmetry and FES-I were found in patients with stroke who trained with MI compared with the other group that did not receive the MI training. Thus, we recommend therapists to add MI in training programs to enhance walking capacity in patients with stroke.

Acknowledgement

The authors wish to thank all patients with stroke who participated in the study and all staff from the Division of Neurology, Department of Medicine Siriraj Hospital and Faculty of Physical Therapy, Mahidol University for their support.

Potential conflicts of interest

None.

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การเพิ่มสมมาตรการเดินด้วยการฝึกกระบวนจินตภาพการเคลื่อนไหวในผู้ป่วยโรคหลอดเลือดสมอง

อนุชัย พึ่งพระรัตนตรัย, สุนีย์ บวรสุนทรชัย, วิมลวรรณ เหียงแก้ว, นาราพร ประยูรวิวัฒน์, สงคราม โชติกอนุชิต

วัตถุประสงค์: *เพื่อศึกษาผลของการฝึกเดินร่วมกับการฝึกกระบวนจินตภาพการเคลื่อนไหวต่อสมมาตรการเดิน และอาการกลัวหกล้มในผู้ป่วยโรคหลอดเลือดสมอง*

วัสดุและวิธีการ: *ผู้ป่วยโรคหลอดเลือดสมอง 14 คน ได้รับการจัดเข้ากลุ่มฝึกกระบวนจินตภาพการเคลื่อนไหว 7 คน และกลุ่มควบคุม 7 คน ผู้เข้าร่วมวิจัยมีความเท่าเทียมกันในเรื่อง อายุ ชนิดของโรคหลอดเลือดสมองข้างที่อ่อนแรง ระยะเวลาที่เกิดโรค และความรุนแรง ผู้เข้าร่วมวิจัยทุกคนได้รับการฝึกกายภาพบำบัด และกลุ่มฝึกกระบวนจินตภาพ การเคลื่อนไหวได้รับการฝึกกระบวนจินตภาพการเคลื่อนไหวหลังจากฝึกกายภาพบำบัด ทั้งสองกลุ่มได้รับการฝึก จำนวน 12 ครั้ง ใน 1 เดือน ตัวแปรในการศึกษานี้ประกอบด้วย ความสมมาตรการเดินซึ่งวัดโดยแผ่นวัดกระจายแรงกดและระดับการกลัวหกล้มวัดโดยแบบประเมิน Fall-efficacy scale international (FES-I) ความแตกต่างทางสถิติระหว่างกลุ่มและภายในกลุ่มทดสอบด้วยสถิติ Mann-Whitney U และ Friedman ANOVA ตามลำดับ*

ผลการศึกษา: *ไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติของความสมมาตรการเดินระหว่างกลุ่มกระบวนจินตภาพการเคลื่อนไหว และกลุ่มควบคุม ความสมมาตรของระยะก้าวและเวลาก้าวสำหรับกลุ่มกระบวนจินตภาพการเคลื่อนไหวมีแนวโน้มดีขึ้นภายหลังการฝึก ความสมมาตรระยะก้าวและคะแนน FES-I มีการเปลี่ยนแปลงดีขึ้นอย่างมีนัยสำคัญทางสถิติ ระหว่างช่วงเวลาการฝึกในกลุ่มกระบวนจินตภาพการเคลื่อนไหว*

สรุป: *กระบวนจินตภาพการเคลื่อนไหวสามารถเพิ่มความสมมาตรการเดินและลดอาการกลัวหกล้มในผู้ป่วยโรคหลอดเลือดสมอง*